Section 4

TROPICAL CYCLONES AND THE MASCARENE & SEYCHELLES ISLANDS

4.1 TROPICAL CYCLONES

Tropical disturbances which develop in the South Indian Ocean off the east coast of the RSA are referred to by all regional weather services as tropical cyclones or tropical storms regardless of the stage of development. Therefore, a classification of 'tropical storm' is not an indication of the system's intensity. Warnings are issued by various weather services, including the Joint Typhoon Warning Center (JTWC) on Guam, and the Mauritian Weather Service, both of which issue position and movement information on these tropical systems. JTWC Guam issues 12-, 24- and 48-h forecasts of the movement and intensity of these systems, and these forecasts are updated every 12 hours.

The tropical cyclone season is from November through April, the highest frequency of occurrence being in January and February. Early in the season (November) these systems generally develop and track east of the Malagasy Republic, often passing near the islands of Mauritius and Reunion (see Fig. 1.1 for location of islands). As the season progresses (Dec - Jan) the source region for these systems shifts westward (Table 4.1).

TABLE 4.1

Mean Position of Origin of Cyclonic Storms in the South Indian Ocean
(Naval Environmental Prediction Research Facility, 1980a)

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
Latitude S. ..	13·0°	13·8°	13·9°	14·6°	14·4°	13·9°	11·1°
Longitude E. ..	66·8°	62·8°	61·8°	62·6°	63·0°	66·0°	68·4°

The potential for storms developing in or passing into the Mozambique Channel is greatest in January and February while the possibility exists throughout the season. Also, by January, storms penetrate farther south before recurving to the southeast (Table 4.2).

TABLE 4.2

Average Latitude of the Point of Recurvature of Tropical Cyclones in the South Indian Ocean (Naval Environmental Prediction Research Facility, 1980a)

	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May
No. of storms	4	12	28	20	13	8	4
Mean south latitude of recurvature	17·0°	17·0°	22·2°	22·2°	20·8°	15·0°	14·0°

In February the tropical cyclone source region and tracks begin to shift back toward the *east* (Table 4.1), and in March, recurvature occurs farther *north* (Table 4.2). April storms generally pass east of the Malagasy Republic and often well east of Mauritius (Naval Environmental Prediction Research Facility, 1980a).

Mean storm tracks have been determined for tropical cyclones which developed over the southwest Indian Ocean from 1950 through 1980. This information, provided by Dr. Ted Tsui of the Naval Environmental Prediction Research Facility (NEPRF), is shown in Figs. 4.1, 4.2 and 4.3. Figure 4.1 depicts a density plot of storm tracks for storms passing east of the Malagasy Republic. Figures 4.2 and 4.3 provide the same information for tropical cyclones passing through the northern and southern Mozambique Channel. Average speed of motion is between six and eight knots, however speed of motion is variable throughout a storm's history. Speed of advance often exceeds these values (speeds occasionally exceed 15 kt) before and after recurvature. Storm motion often slows significantly at recurvature . Storms pass east of the Malagasy Republic more frequently than to the west (i.e., in the Mozambique Channel).

When passing east of the Malagasy Republic the systems generally recurve rapidly toward the southeast. Systems developing in or moving into the Mozambique Channel move more slowly toward the south then, generally, recurve rapidly toward the southeast after passing through the channel. Tropical cyclones in the southwest Indian Ocean are generally small systems compared to North Pacific Ocean typhoons and not so intense. The maximum winds average 68 kt (based on data from seventeen storms) for tropical storms passing east of the Malagasy Republic and 56 kt (based on data from five tropical storms) for the systems in the Mozambique Channel. These values were obtained using data provided by NEPRF.

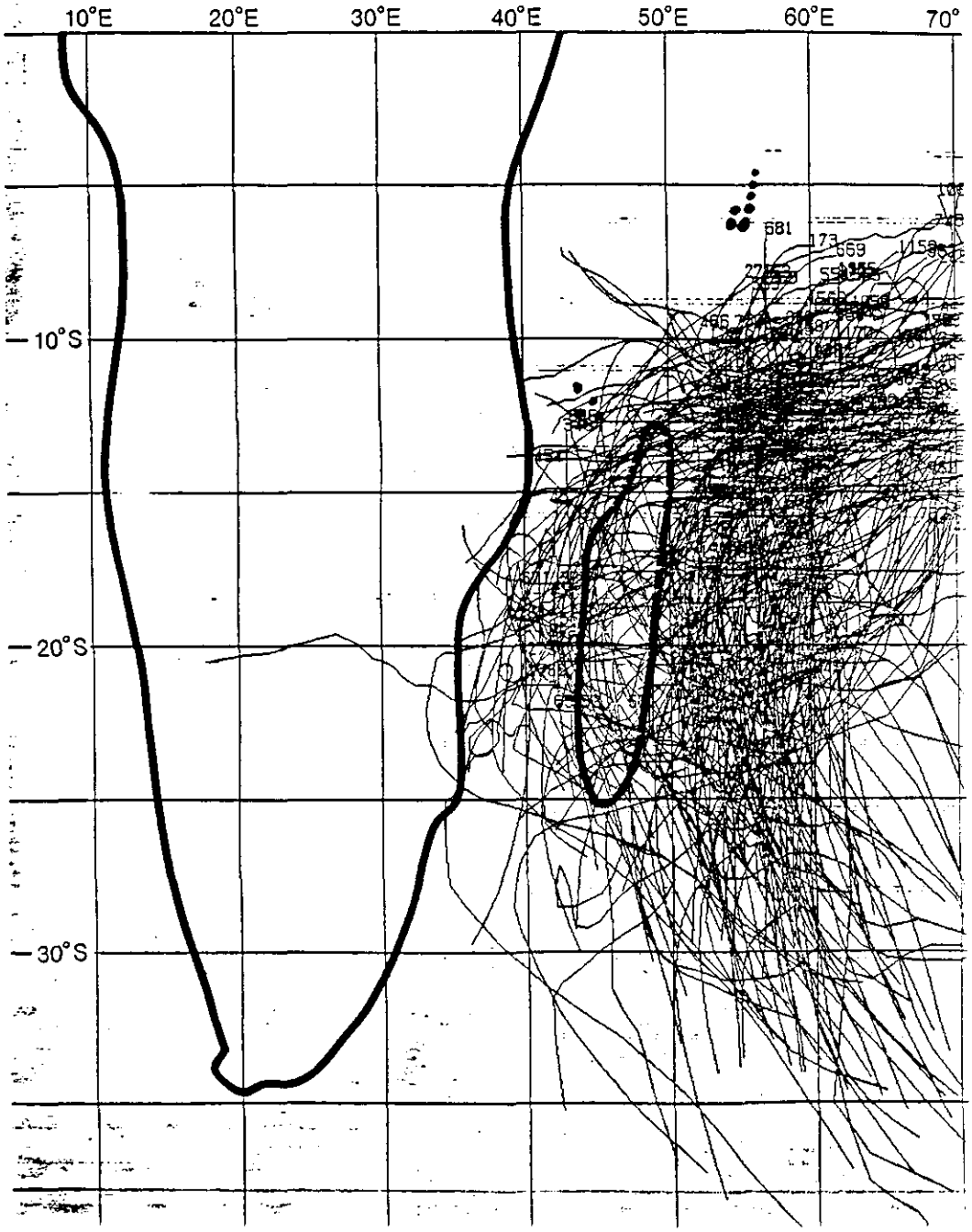

Fig. 4.1. Density Plot of Tropical Cyclone Tracks East of the Malagasy Republic (i.e., passing through area: 47°E-60°E, 11°S-25°S)

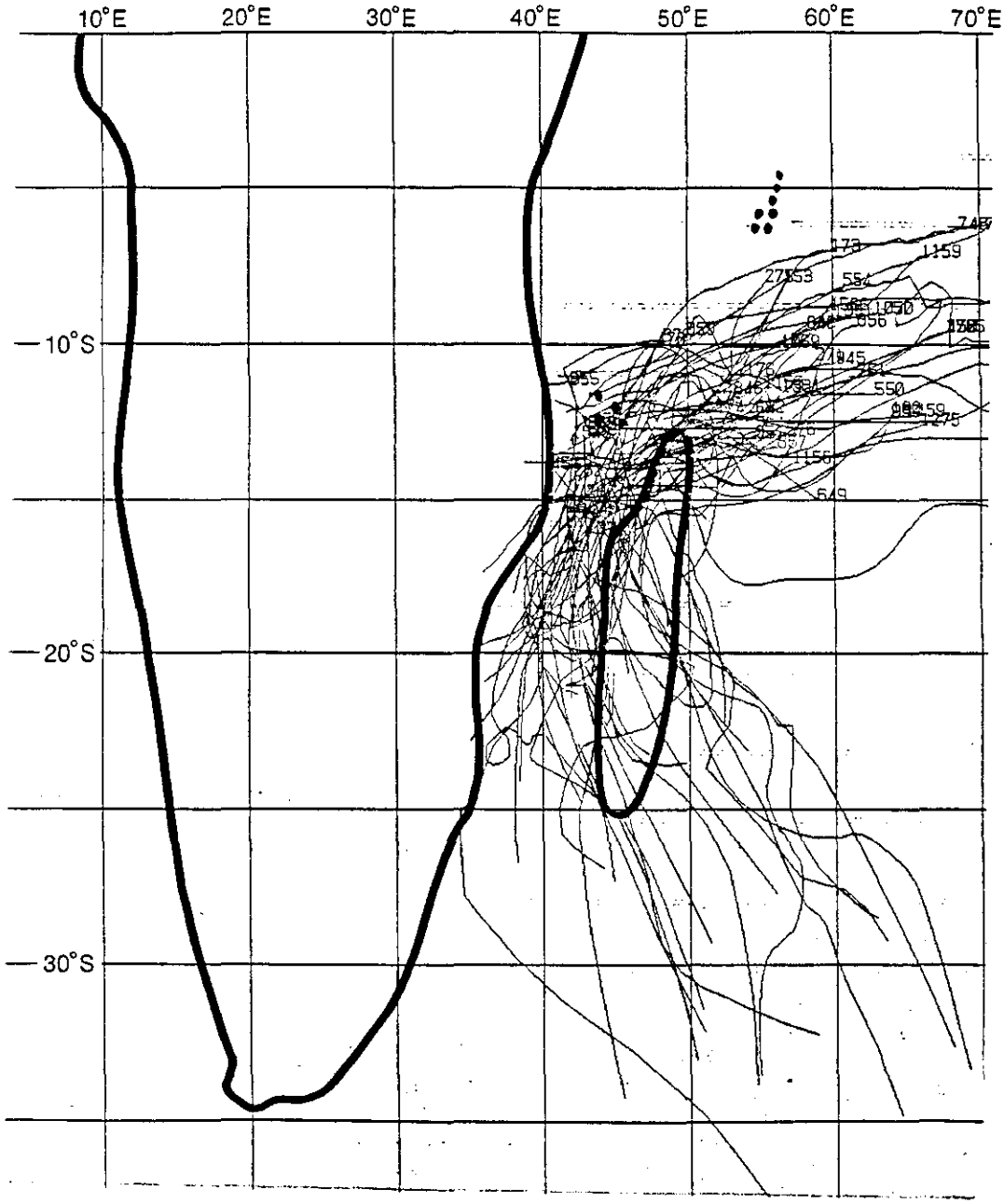

Fig. 4.2. Density Plot of Tropical Cyclone Tracks Affecting the Northern Mozambique Channel (i.e., passing through area: 41°E-49°E, 11°S-16°S)

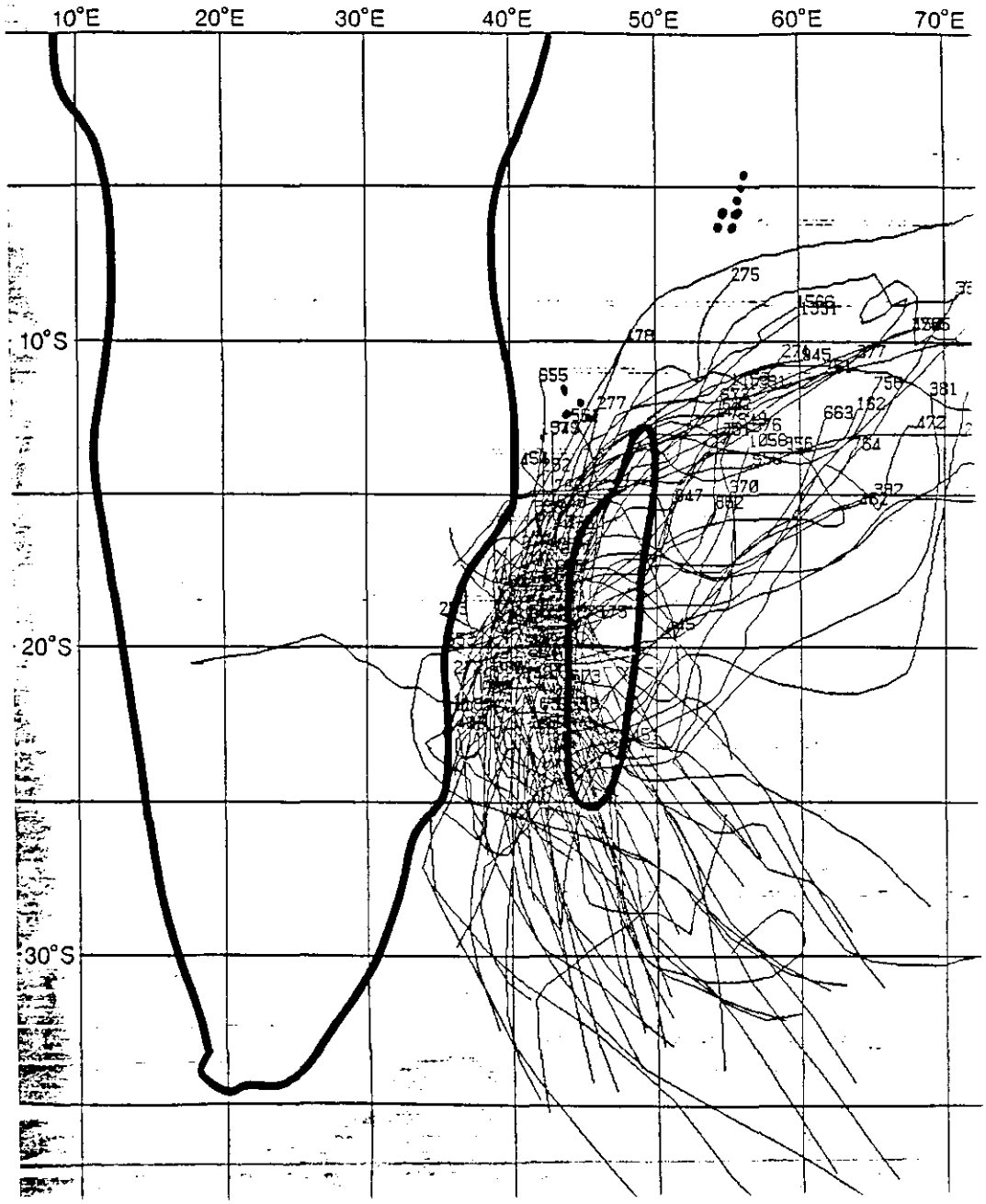

Fig. 4.3. Density Plot of Tropical Cyclone Tracks Affecting the Southern Mozambique Channel (i.e., passing through area: 35°E-45°E, 16°S-25°S)

During the tropical cyclone season, strong high pressure cells are migrating eastward across the south Indian Ocean, south of the Malagasy Republic. If a tropical cyclone advances (relatively) toward one of these migrating anticyclones, surface winds between the two systems are increased significantly. Strong gradient winds (20-30 kt) are likely to be extended in the direction of the high cell. An example is shown in Figs. 4.4 and 4.5 in which 20-30 kt winds extend over 600 n mi south-southeast of the tropical cyclone center. Figure 4.6 is a mosaic from the polar orbiting NOAA-4 satellite which passed near the Malagasy Republic at approximately 0600 GMT (six hours before the analysis time of Fig. 4.5).

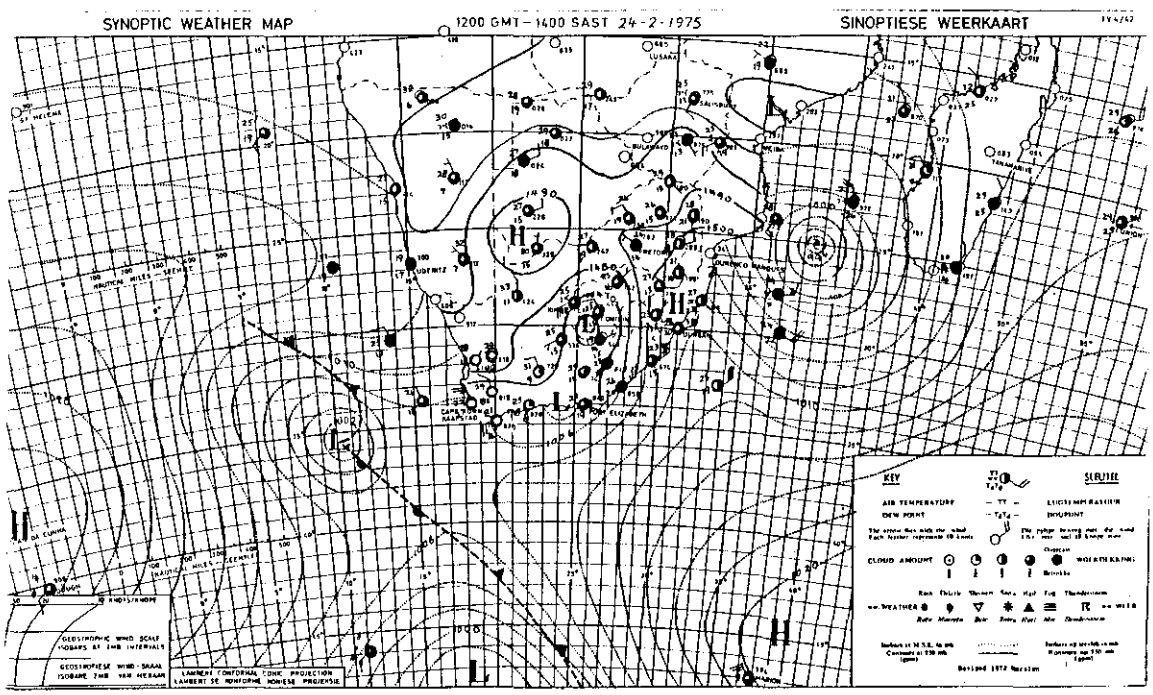

Fig. 4.4. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 24 February 1975

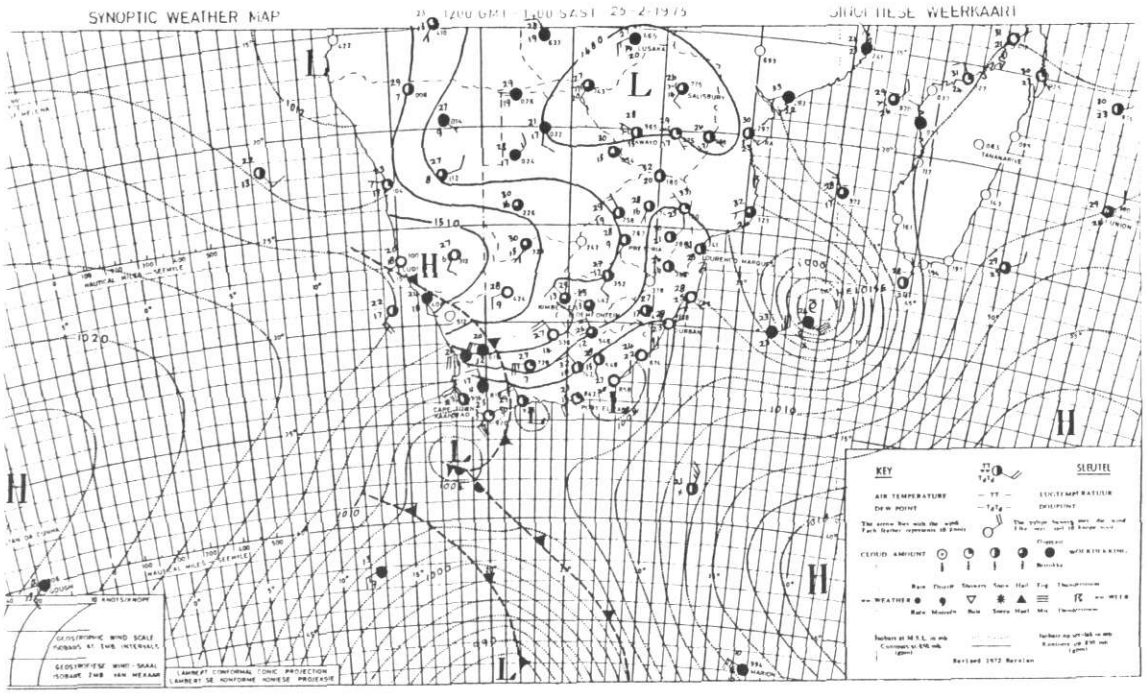

Fig. 4.5. Same as Fig. 4.4 except for 1200 GMT 25 February 1975

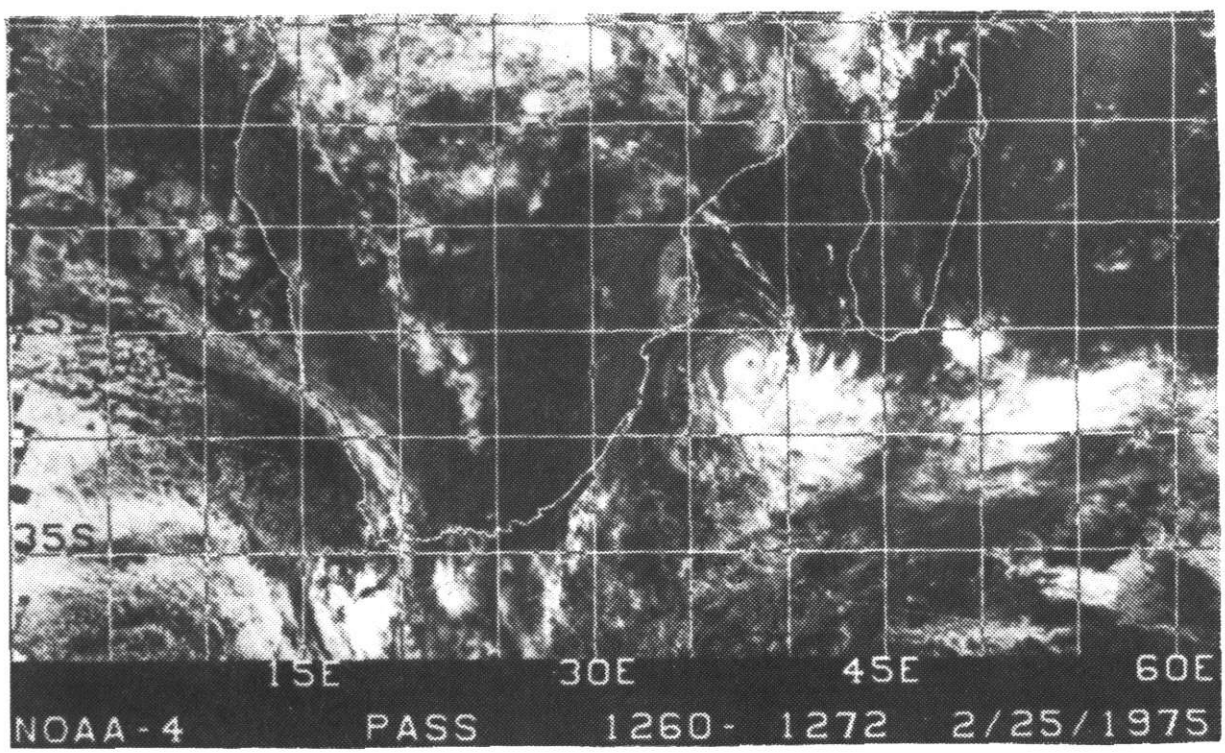

Fig. 4.6. NOAA 4 Visible Satellite Imagery (at approx. 0600 GMT at 45°E) 25 February 1975

4.2 WEATHER ASSOCIATED WITH TROPICAL CYCLONES

Weather phenomema over Mozambique, the Malagasy Republic and the surrounding south Indian Ocean vary significantly, depending on the track and intensity of the system.

4.2.1 Tropical Cyclones East of the Malagasy Republic

The following discussion is a case study of tropical cyclone Danae (Figs. 4.7 - 4.11). Winds[8] on the Malagasy Republic's north and central east coast become moderate southeasterly as the tropical cyclone approaches from the northeast (Figs. 4.7 and 4.8). As the weather system continues southwestward, the northeast and central coasts of the Malagasy Republic experience south to southeasterly winds, broken to overcast clouds and developing rain showers prior to the cyclone passage. As the storm crosses into the island's northern and central interior (Figs. 4.9 and 4.10), northeasterly winds dominate over most of the east coast (except southerly winds found in the southern quadrant of the storm). Overcast clouds and rain also develop over most of the east coastal regions (heavier rains south of the system due to orographic lifting of onshore flow). Wind over the southwest coast becomes moderate southerly, while moderate westerly wind develops over the west coast north of the tropical cyclone. Overcast conditions and rain showers (frequently heavy) develop over the west coast north of the system. Rain shower activity decreases south of the center. After the tropical cyclone passes into the Mozambique Channel, coastal winds south of the system become moderate to strong northeasterly (Fig. 4.11). North of the system coastal wind is moderate northwesterly.

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[8] Discussions of wind and other weather phenomena over coastal Mozambique and the Malagasy Republic make use of observations from land-based stations. Wind speeds mentioned as 'typical' represent conditions ashore. Conditions over the coastal waters are likely to be more severe.

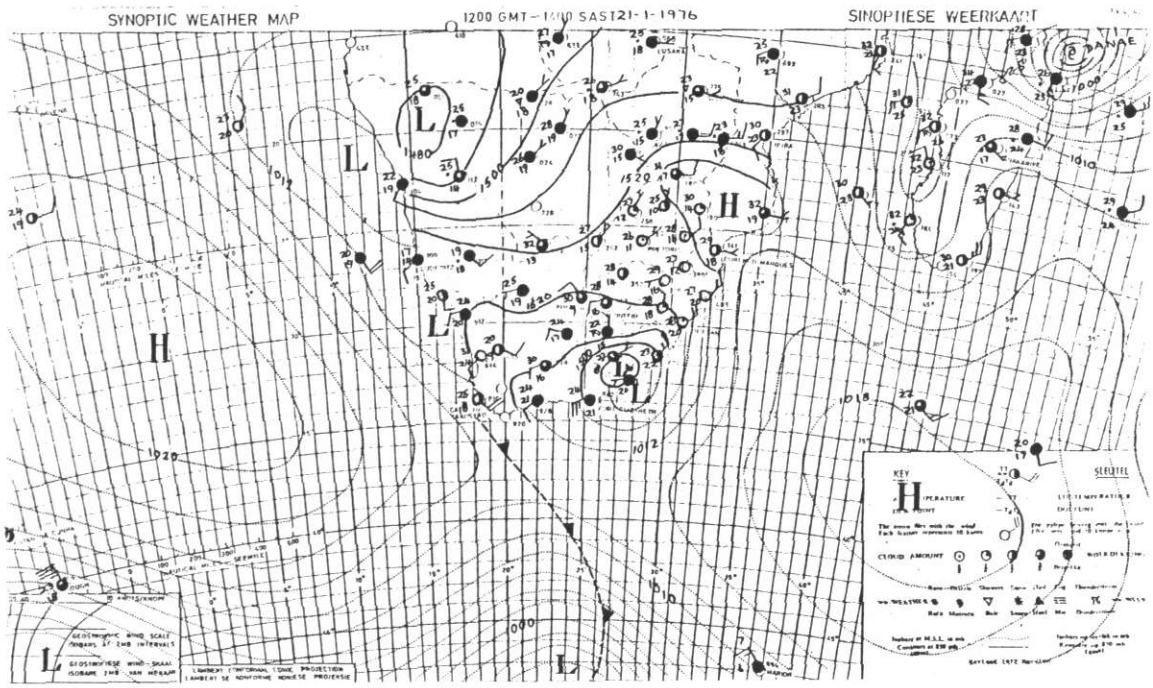

Fig. 4.7. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 21 January 1976

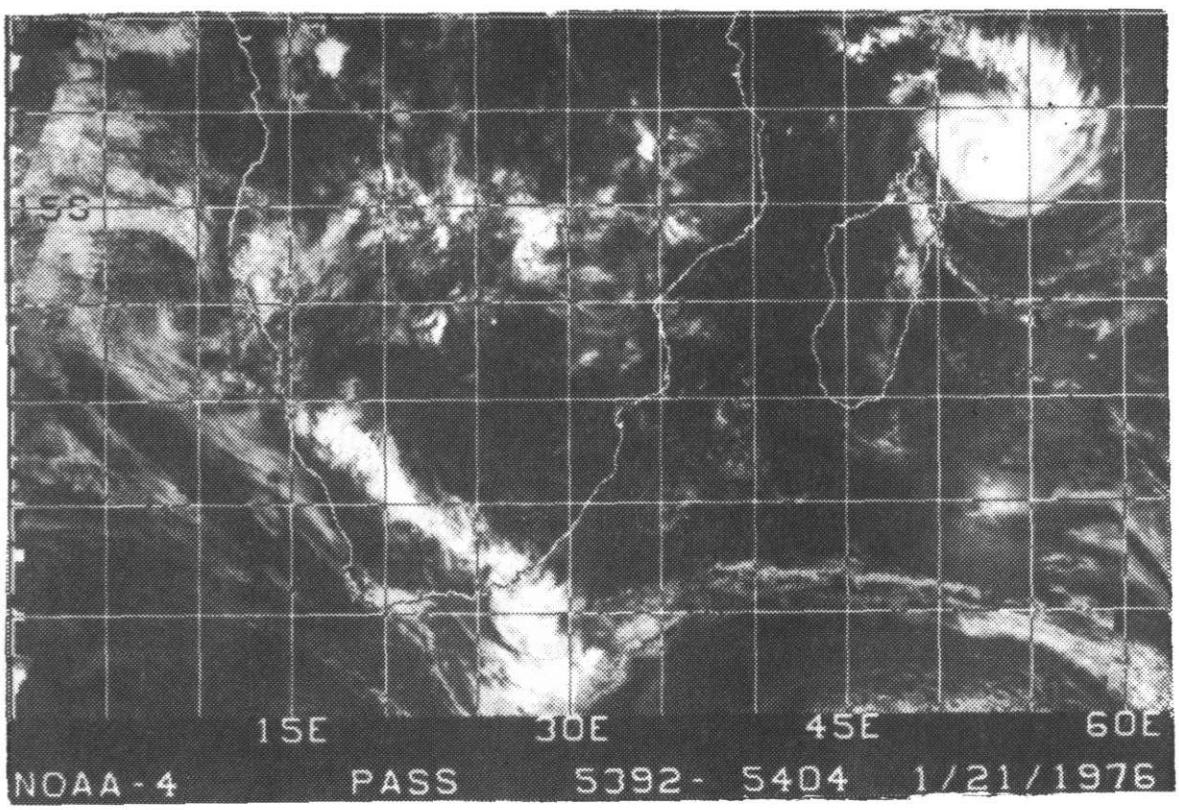

Fig. 4.8. NOAA 4 Visible Satellite Imagery (at approx. 0600 GMT at 45°E) 21 January 1976

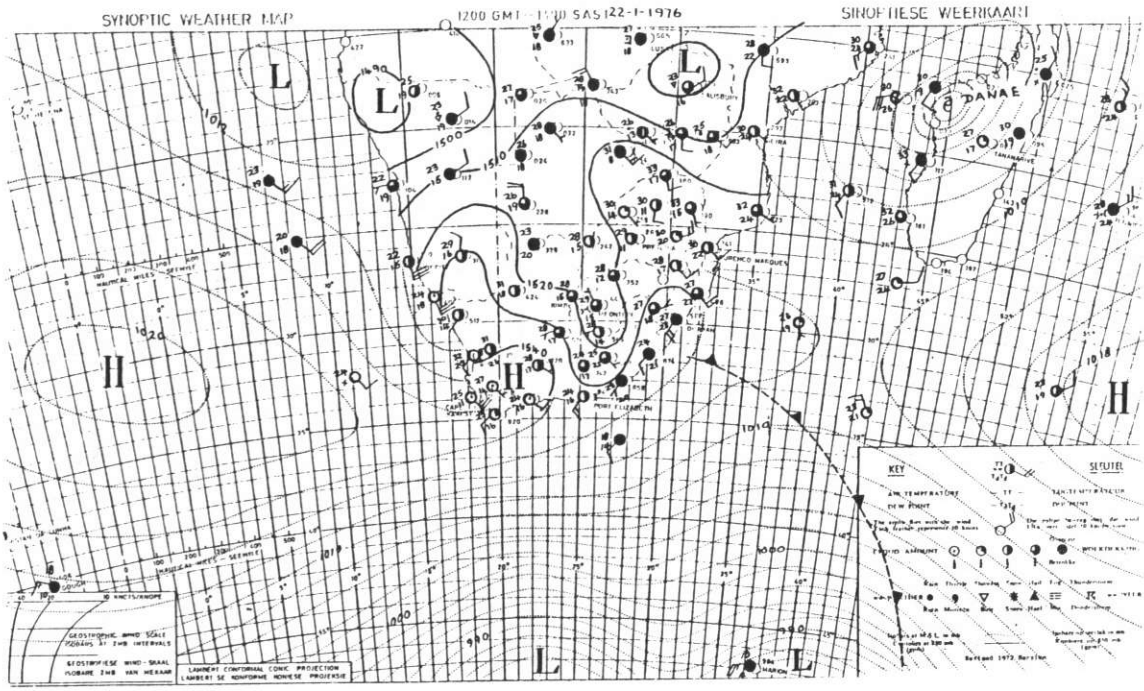

Fig. 4.9. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 22 January 1976

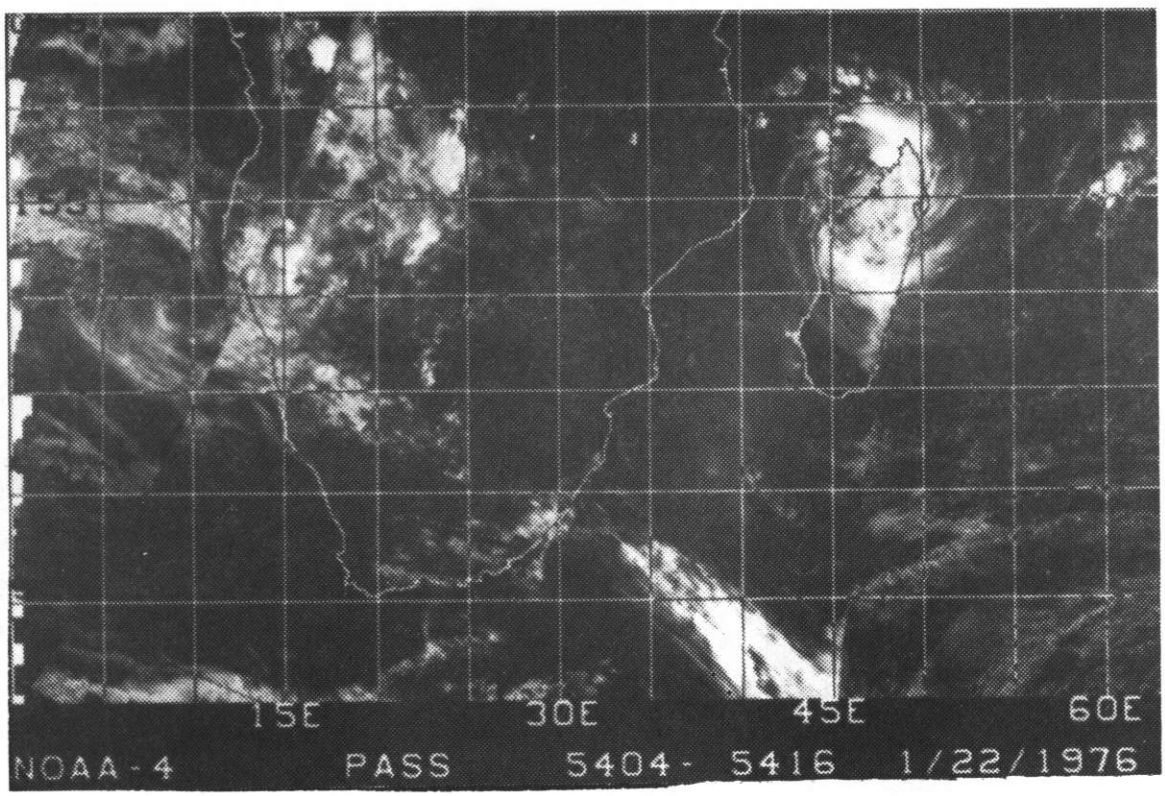

Fig. 4.10. NOAA 4 Visible Satellite Imagery (at approx. 0600 GMT at 45°E) 22 January 1976

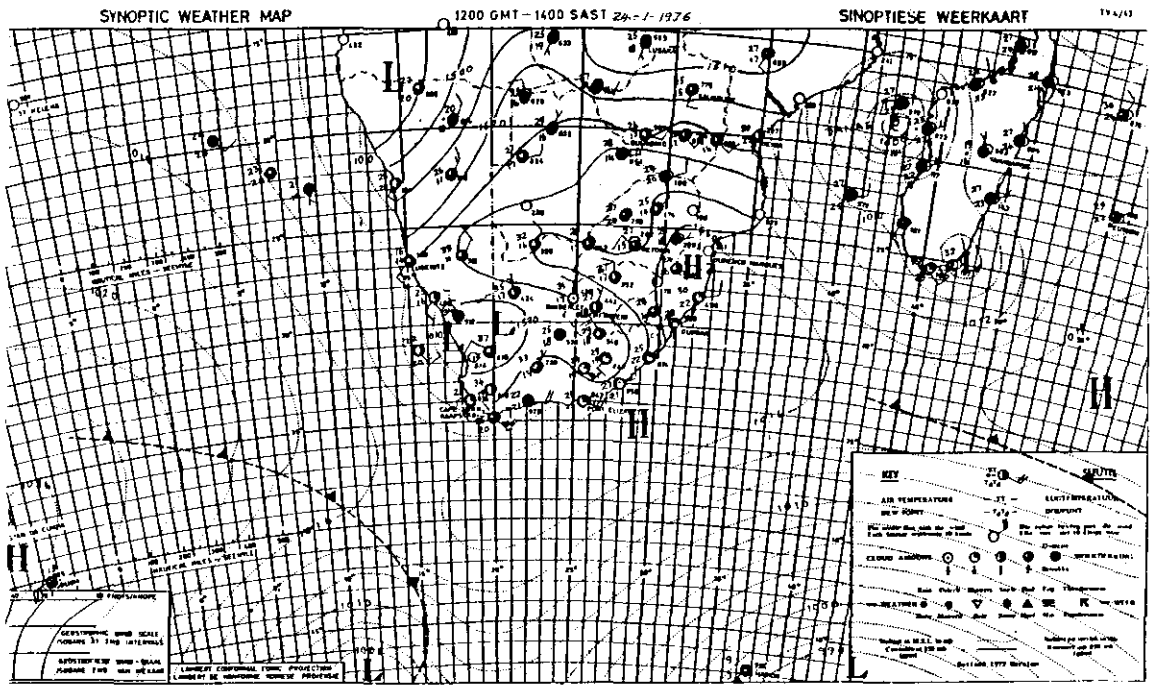

Fig. 4.11. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis:. 1200 GMT 24 January 1976

4.2.2 Tropical Cyclones in the Mozambique Channel

a. Weather in Mozambique

Tropical cyclones moving into the channel from the north are frequently in the developing stage. Wind over northern coastal Mozambique is likely to become moderate southwesterly or southerly (Figs. 4.12 - 4.16). Broken to overcast cloud conditions and light to moderate rains develop. If the tropical cyclone moves to the east side of the Mozambique Channel, the system will have little effect over Mozambique. Storms developing or moving into the northern portion of the Mozambique Channel seldom continue southward on the west side. More frequently the storms move down the east side of the Channel and occasionally a system crosses over the Malagasy Republic into the Indian Ocean.

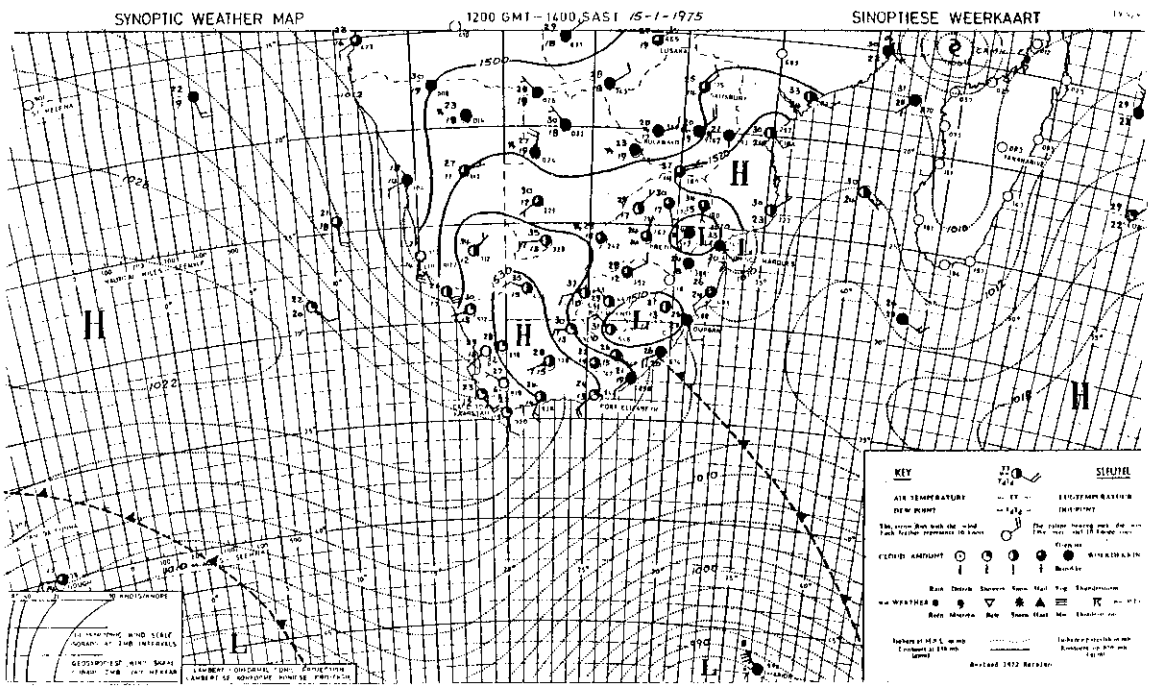

Fig. 4.12. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 15 January 1975

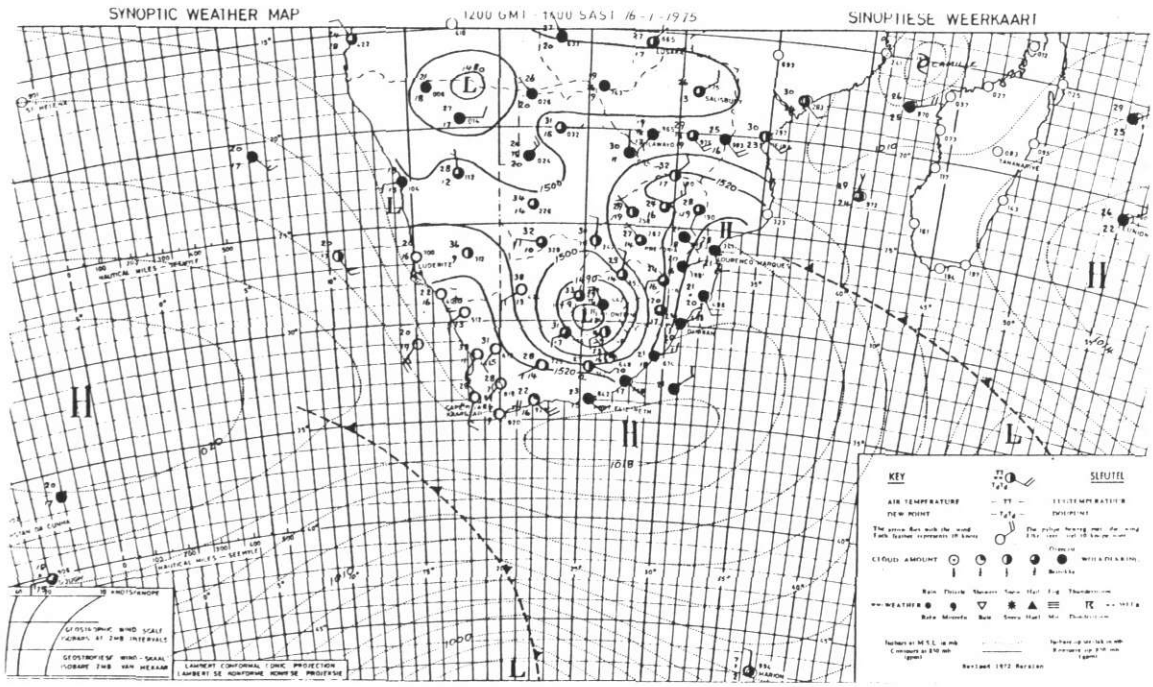

Fig. 4.13. Same as Fig. 4.12 except for 1200 GMT 16 January 1975

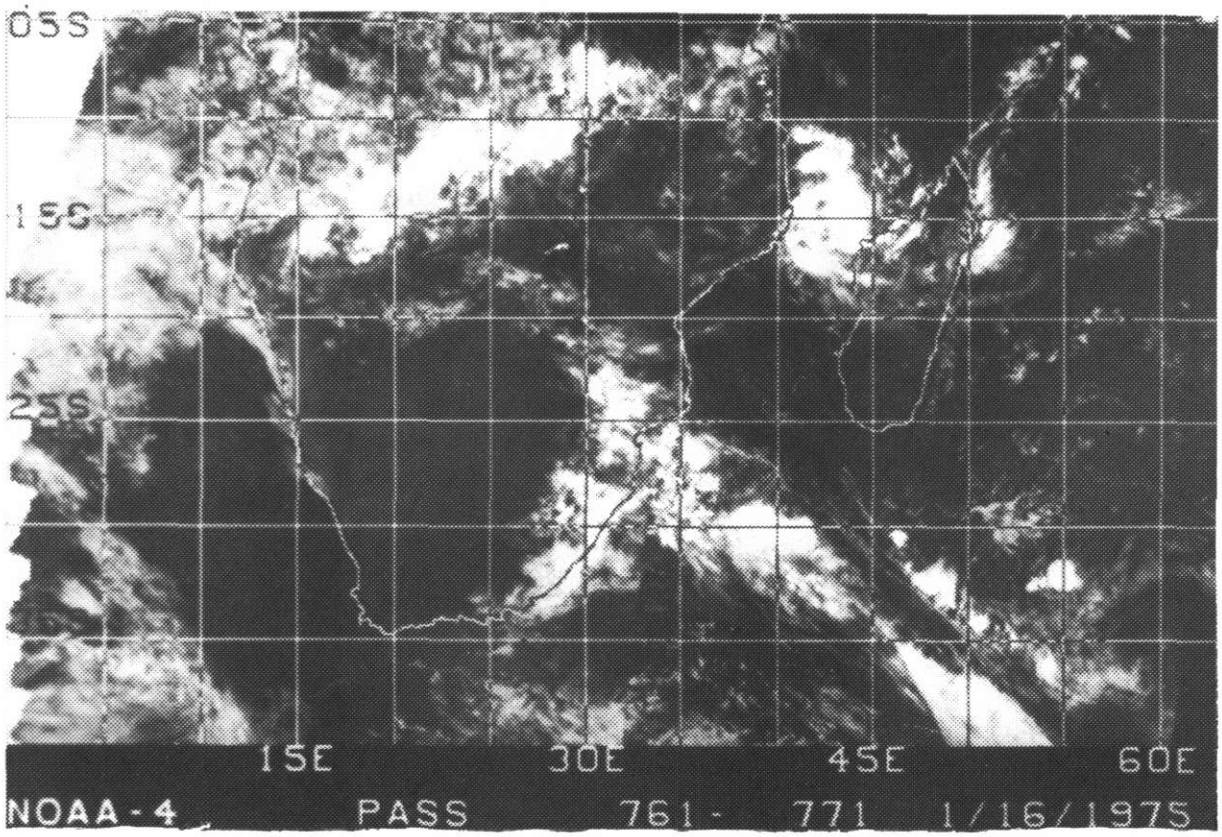

Fig. 4.14. NOAA 4 Visible Satellite Imagery (at approx. 0600 GMT at 45°E) 16 January 1975

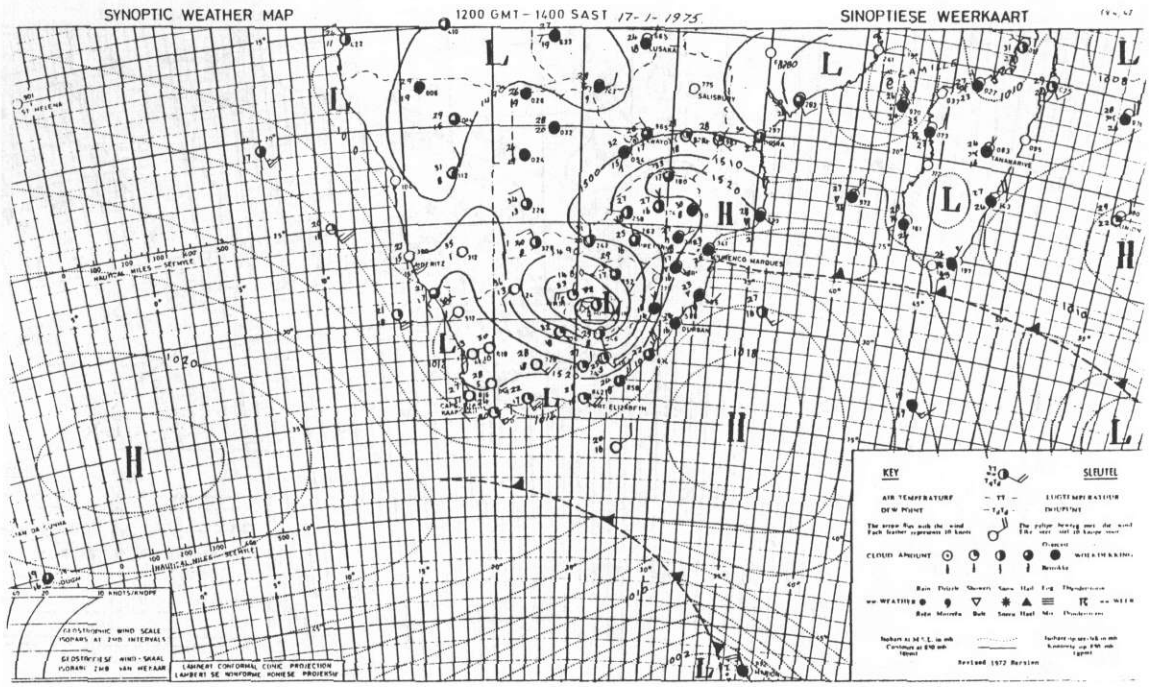

Fig. 4.15. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 17 January 1975

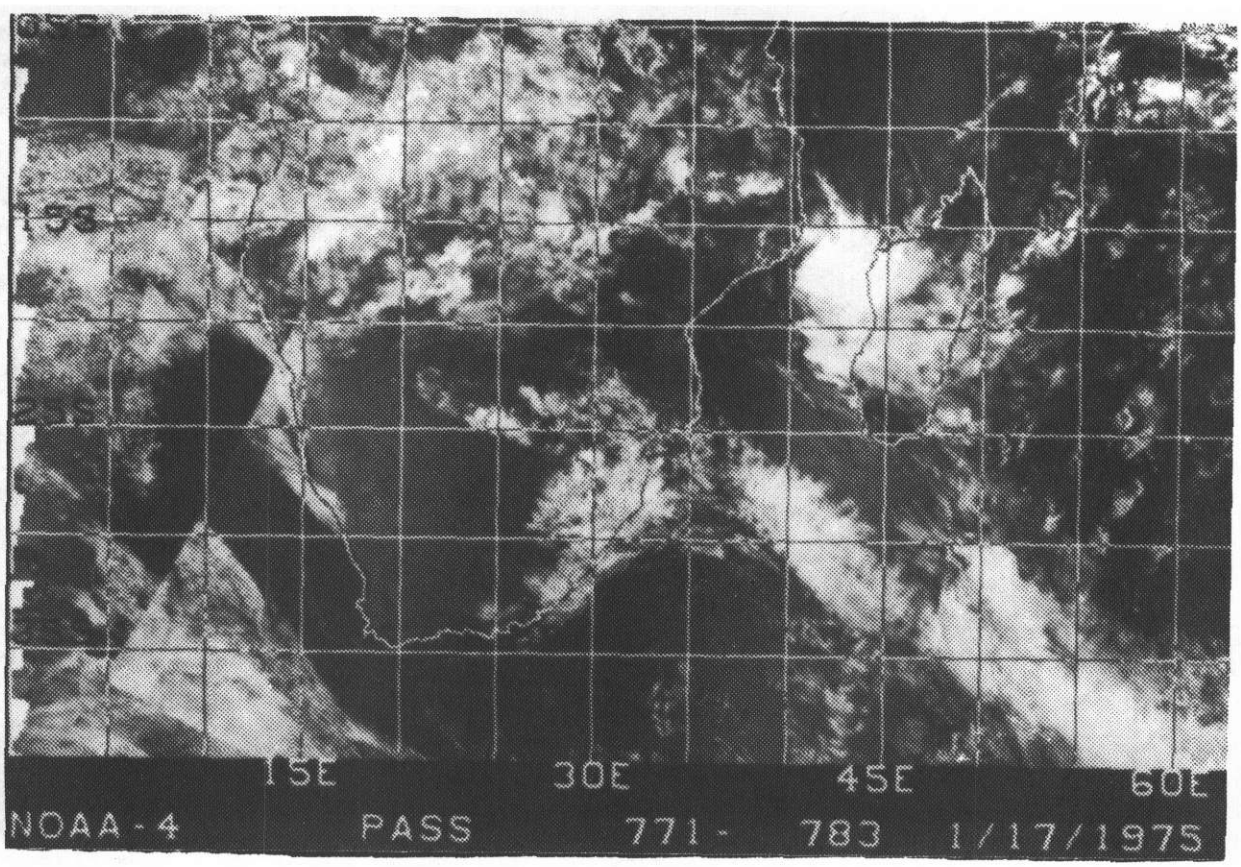

Fig. 4.16. NOAA 4 Visible Satellite Imagery (at approx. 0600 GMT at 45°E) 17 January 1975

A continuation of Danae's track is shown in Figs. 4.11, 4.17 - 4.19) to illustrate weather associated with the occasional cyclone tracking to the west side of the Channel. As the storm moves southwestward, winds over the northern coast of Mozambique are likely to become southwesterly. Heavy rain showers develop. Winds over the central coastal region of Mozambique become moderate to strong from the southeast (onshore) then southwest as the storm passes. Heavy rains develop along the central coast north and south of the tropical cyclone center. The winds over the south coastal region become south to southeast and begin to strengthen as the tropical cyclone continues southward (Figs. 4.17, 4.18). Winds over the northeast coast develop an offshore component. If landfall occurs over the central or southern Mozambique coast the system dissipates rapidly and winds weaken to the north and south (Fig. 4.19). Heavy rainfall and flooding are likely over large portions of the coast and interior of Mozambique. If landfall does not occur the system is likely to pass southward out of the Mozambique Channel. Weather over the central and southern coasts clears. Wind over the southern coastal region shifts to southwesterly and weakens. Recurvature of the cyclone to the southeast occurs rapidly.

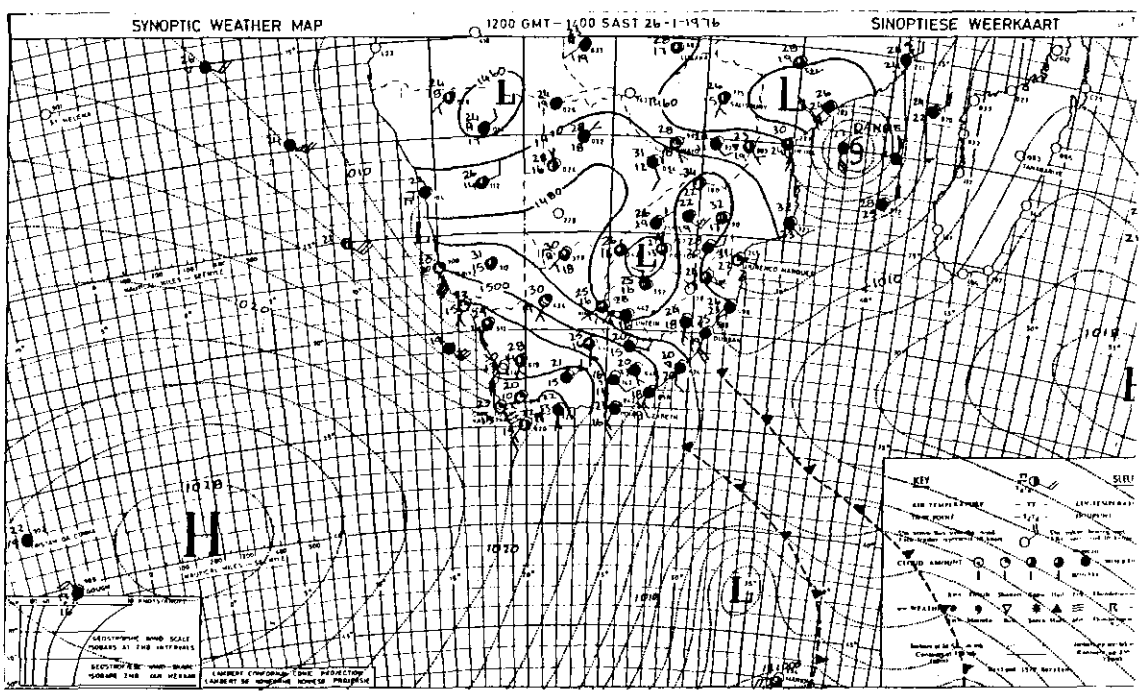

Fig. 4.17. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 26 January 1976

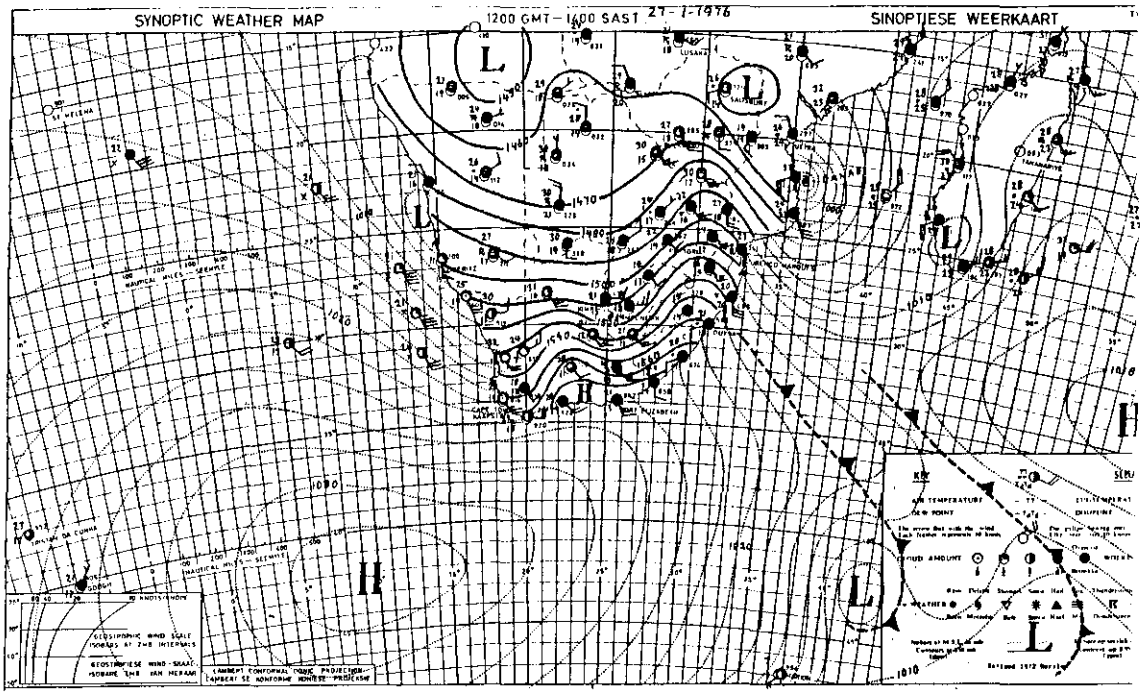

Fig. 4.18. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 27 January 1976

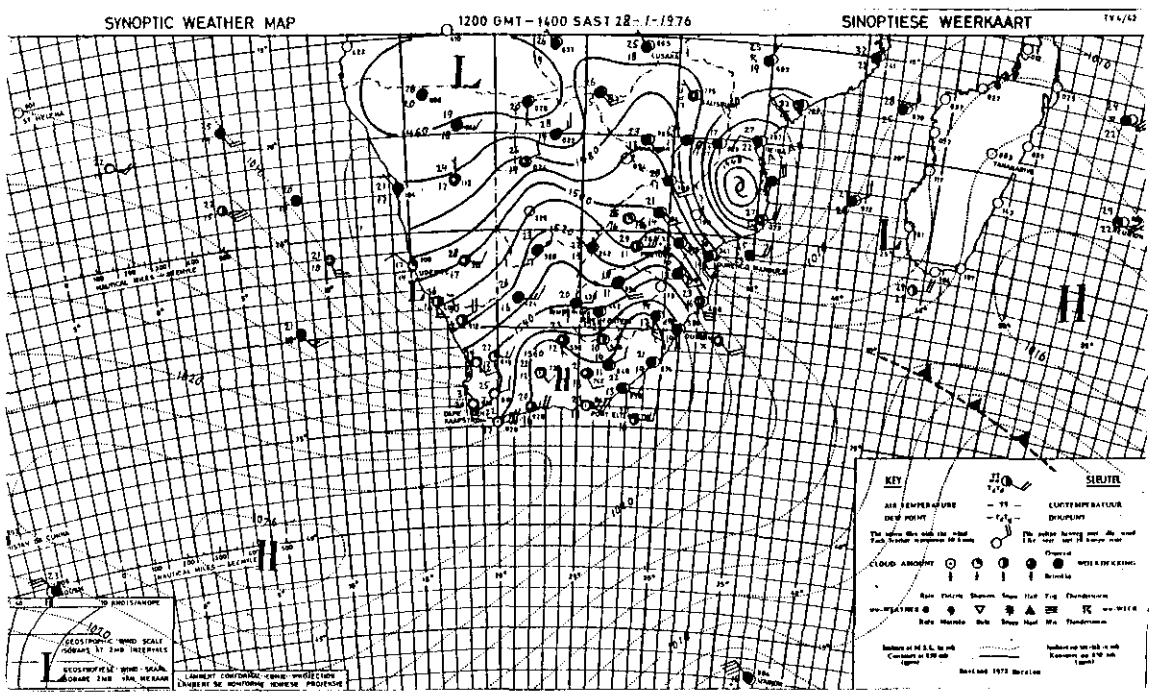

Fig. 4.19. Same as Fig. 4.18 except for 1200 GMT 28 January 1976

Tropical cyclones frequently re-intensify when moving from the Malagasy Republic into the Mozambique Channel. Motion of storms in the Mozambique Channel is occasionally slow and erratic as in the case of tropical cyclone Caroline (Figs. 4.20 - 4.22) (i.e., tropical cyclone Caroline meandered *northward* for several days before dissipating over southern Mozambique). However, storms generally move southward out of the channel then rapidly recurve southeastward into the Indian Ocean.

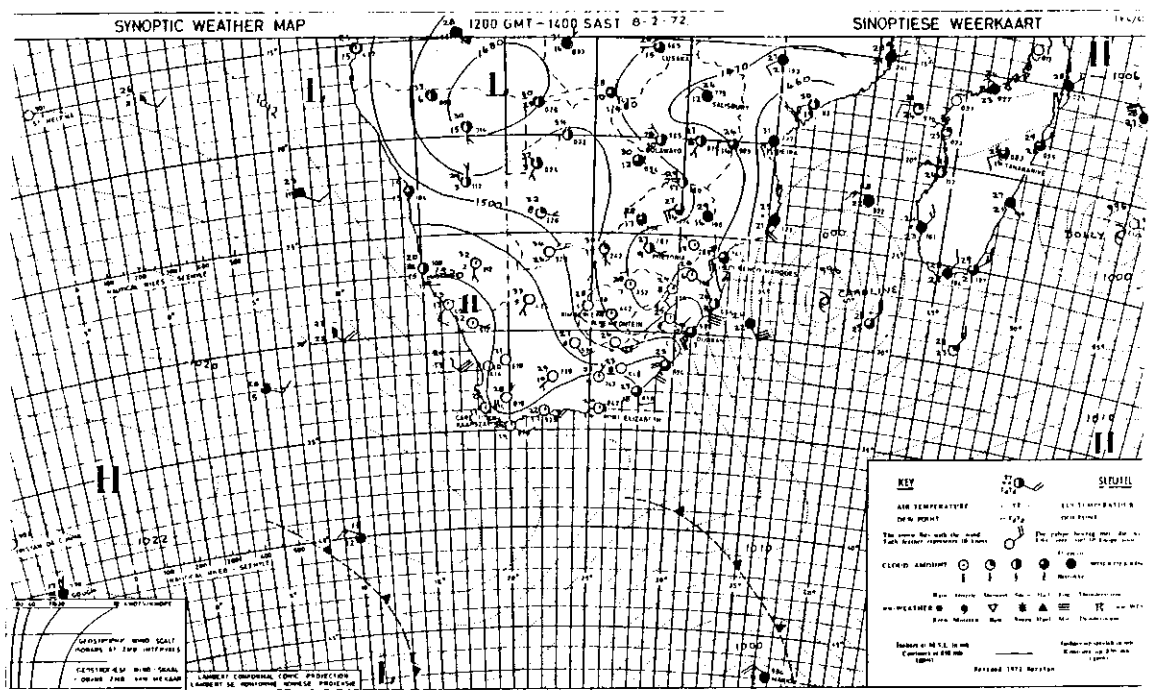

Fig. 4.20. Same as Fig. 4.18 except for 1200 GMT 8 February 1972

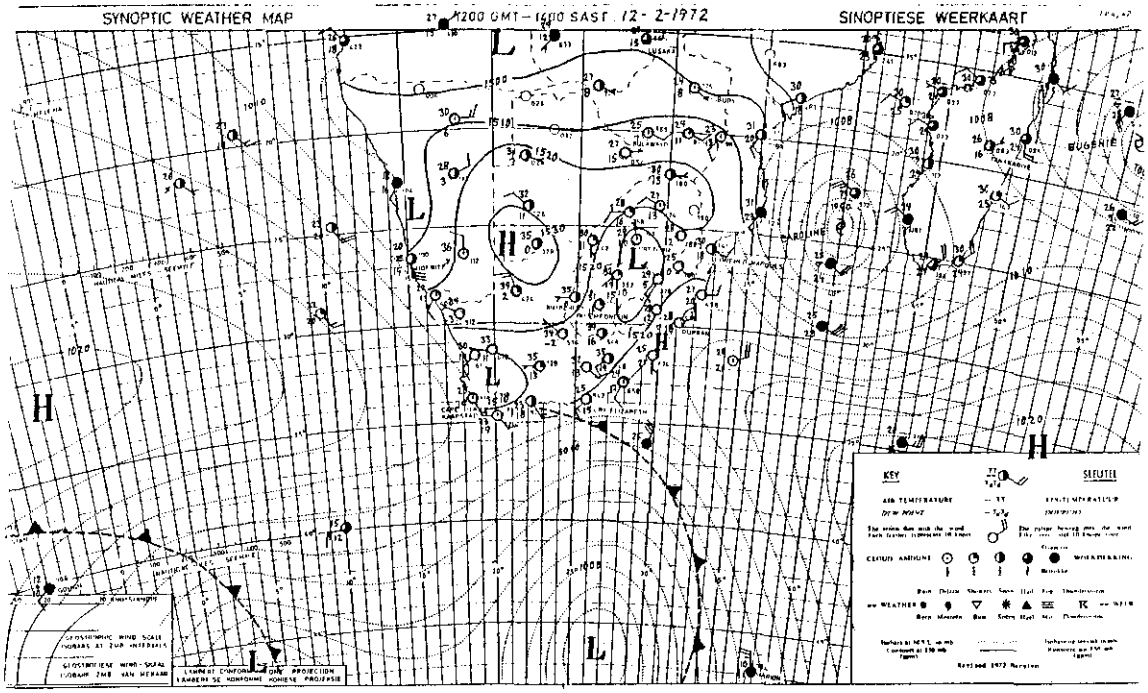

Fig. 4.21. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 *mb (over Continent) Analysis: 1200 GMT 12 February 1972*

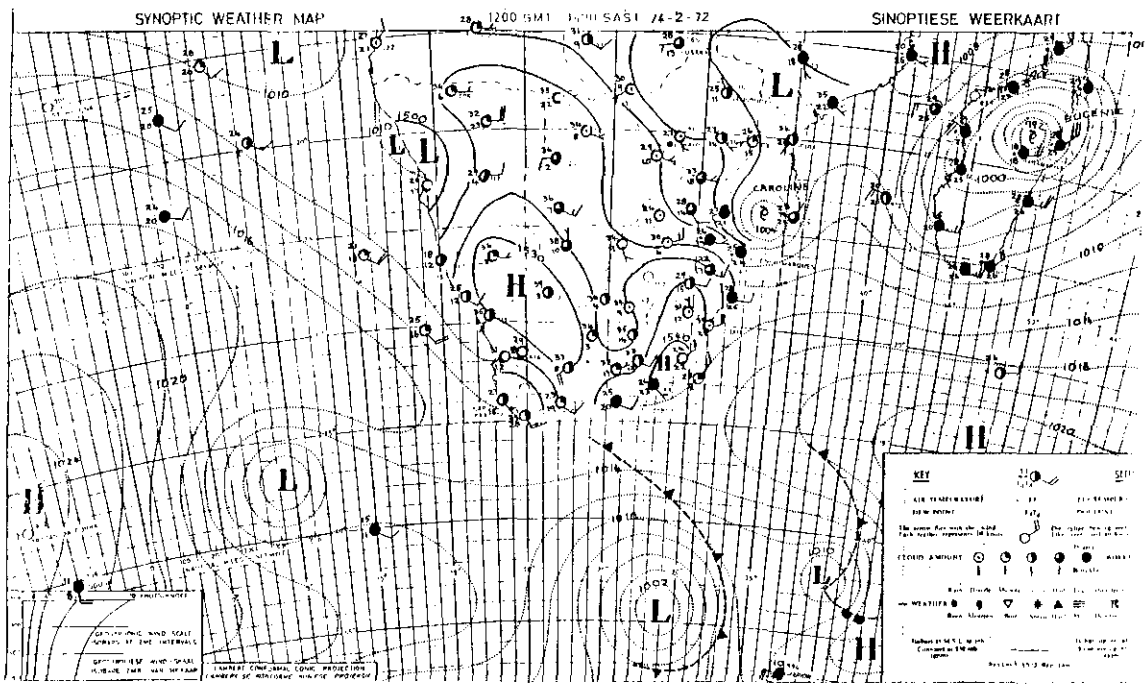

Fig. 4.22. Same as Fig. 4.21 except for 1200 GMT 14 February 1972

b. Weather over the Malagasy Republic

Tropical cyclones which move to the east side of the Mozambique Channel significantly affect the weather of the Malagasy Republic. Occasionally, storms entering the northern Mozambique Channel move southeastward over the northwest coast of the Malagasy Republic. Storms crossing the Malagasy Republic from west to east follow various and sometimes erratic paths, and the weather associated with these systems varies. A brief case study follows on tropical cyclone Charlotte (Figs. 4.23 - 4.26). Tropical cyclone Charlotte appears to be representative of a typical storm passage over the island. Winds on the northwest coast become strong northerly as the system approaches, and heavy rainfall ensues (Fig. 4.23). Over the central western coast, southwesterly winds develop as the system moves across the island (Fig. 4.24). Broken/overcast clouds and rain showers develop on the west coast. As the storm advances toward the east side of the Malagasy Republic, winds over the central and southwest coasts become westerly (Fig. 4.25). Rains (frequently heavy) are likely to develop over the southeast coast. When the system moves over the Indian Ocean, winds on the east coast north of the system develop an offshore component, while winds over the southeast coast become southeasterly (Fig. 4.26). The likelihood of offshore winds over the northern and central east coast increases with the horizontal dimensions of the tropical cyclone. Tropical cyclones often re-intensify when moving from the Malagasy Republic to the Indian Ocean. The radius of 30 kt winds will increase significantly.

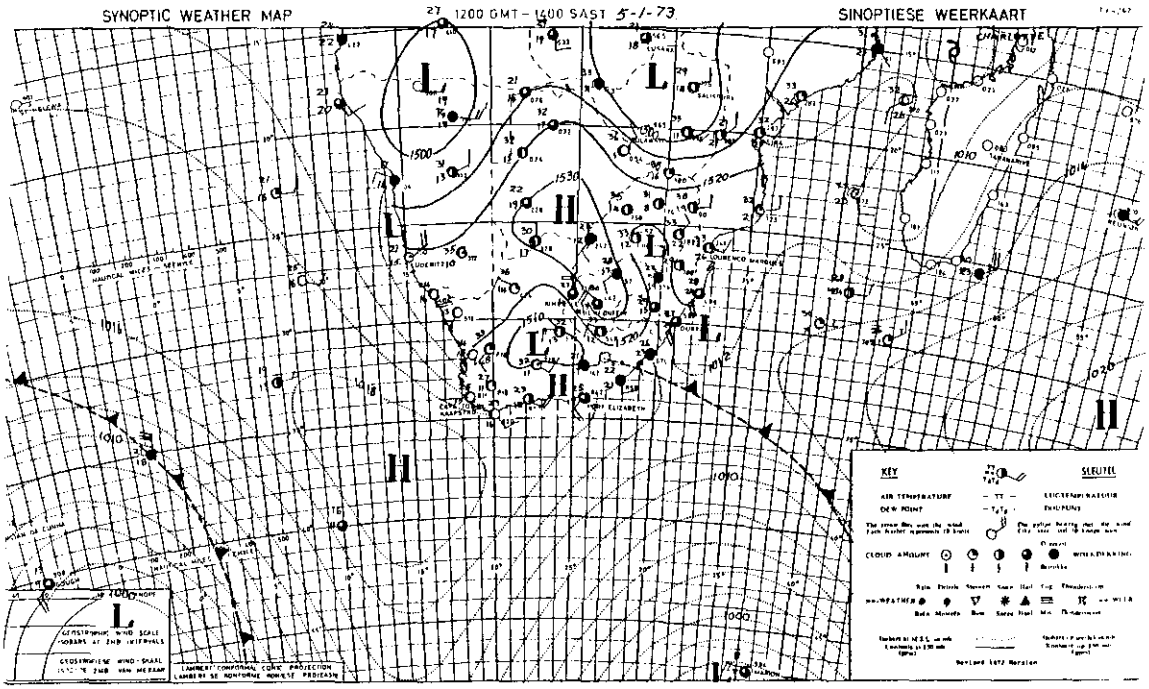

Fig. 4.23. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 5 January 1973

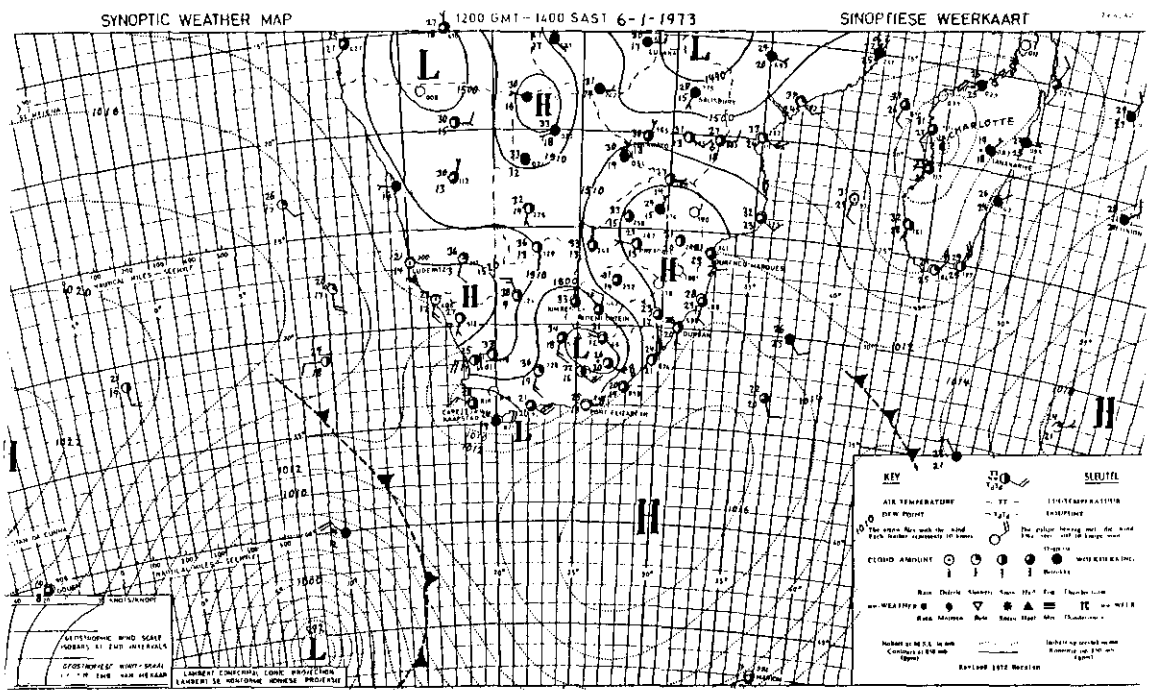

Fig. 4.24. Same as Fig. 4.23 except for 1200 GMT 6 January 1973

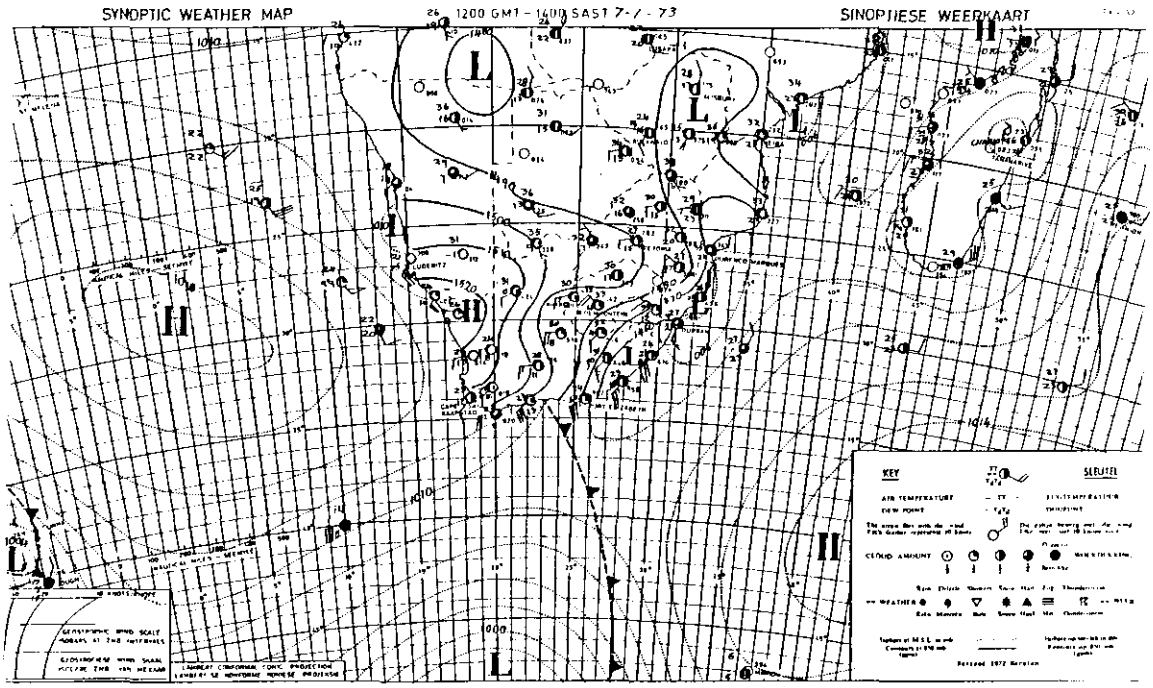

Fig. 4.25. Same as Fig. 4.23 except for 1200 GMT 7 January 1973

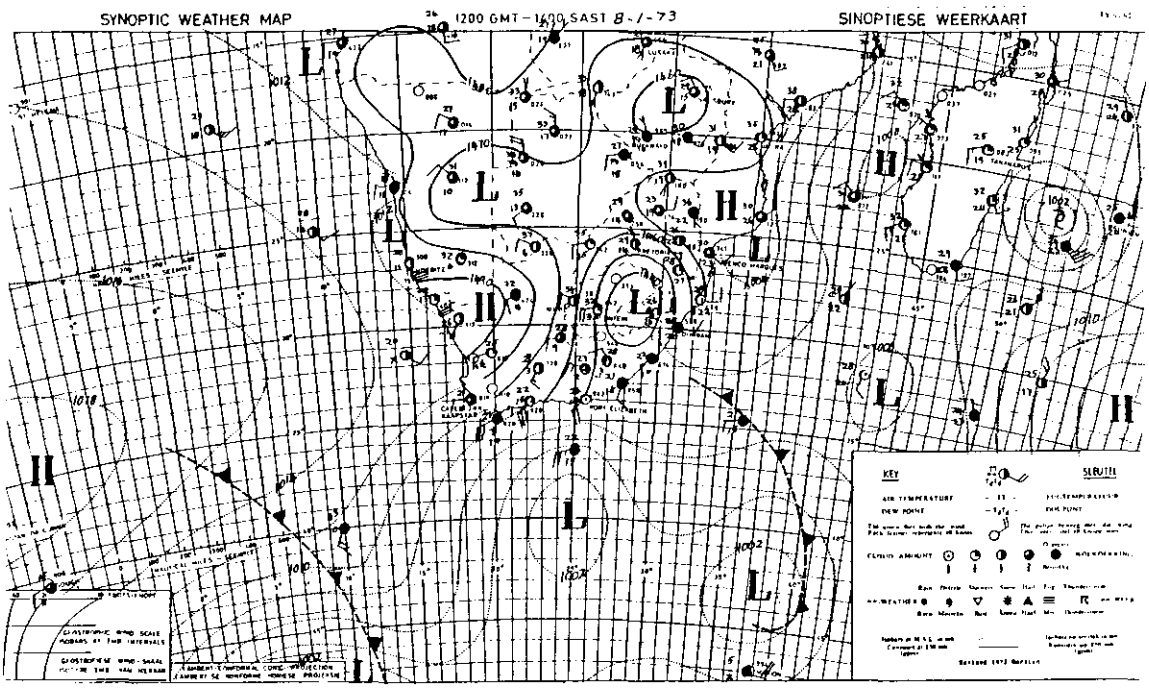

Fig. 4.26. Same as Fig. 4.23 except for 1200 GMT 8 January 1973

Tropical cyclones occasionally cross the southern Malagasy Republic from the Mozambique Channel. As tropical cyclone Camille approaches the southwest coast, winds over most of the central northwest coast become moderate northwesterly (Fig. 4.27). This wind is strengthened if ridging occurs over the Mozambique Channel from the north. Wind south of the system becomes moderate easterly (offshore). Rains and overcast conditions develop over the central west coast in advance of landfall. Winds shift to westerly on the west coast, and northerly on the east coast, as the system passes over the southern Malagasy Republic (Fig. 4.28). On the southeast coast (south of the system) wind becomes northeasterly with overcast conditions and rain showers (Fig. 4.28). Rain showers decrease northward from the system and terminate over the central east coast. When the system moves out over the Indian Ocean the winds over the southeast coastal region become southerly and decrease (Fig. 4.29).

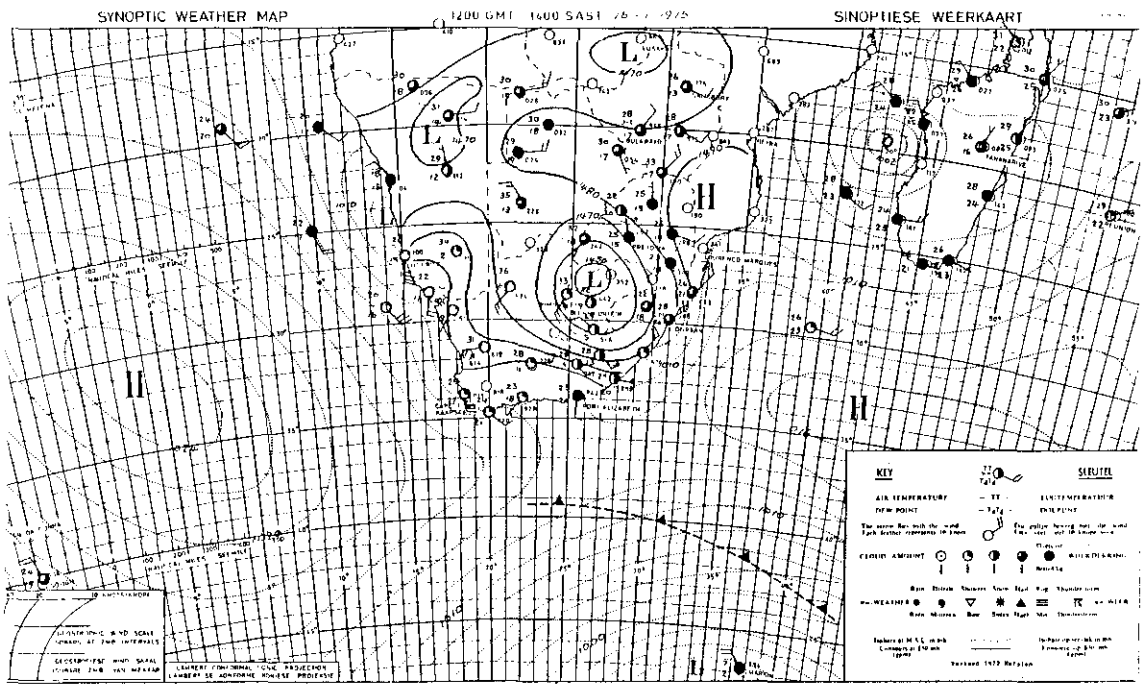

Fig. 4.27. Republic of South Africa Weather Bureau Surface (over Ocean) and 850 mb (over Continent) Analysis: 1200 GMT 18 January 1975

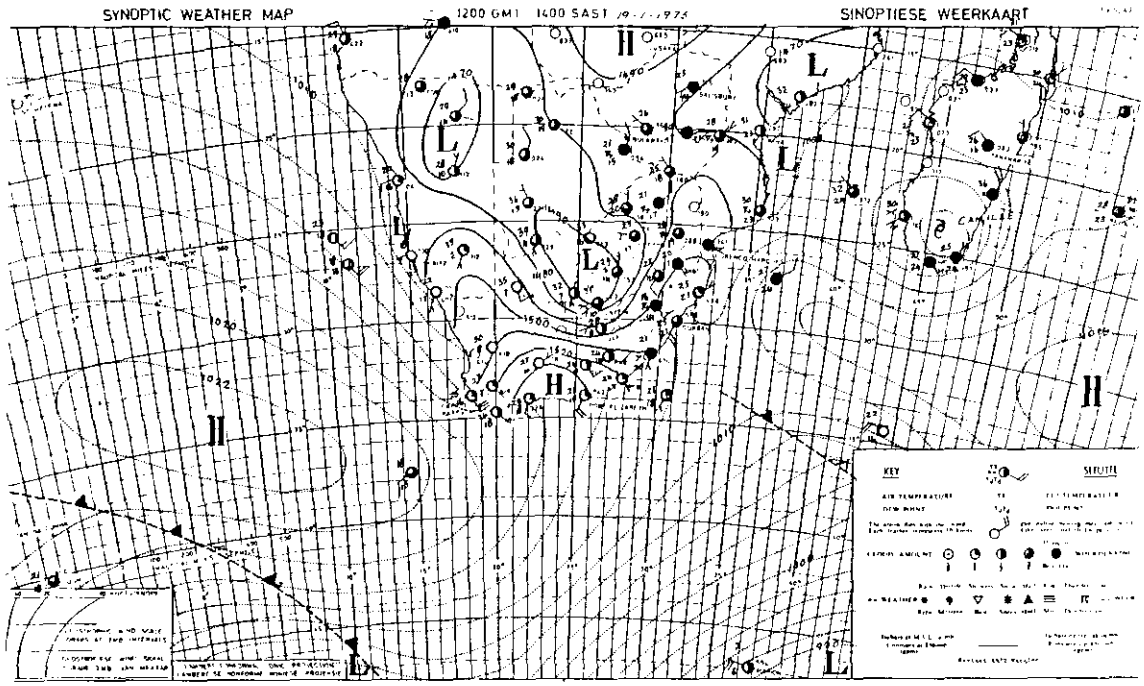

Fig. 4.28. Same as Fig. 4.27 except for 1200 GMT 19 January 1975

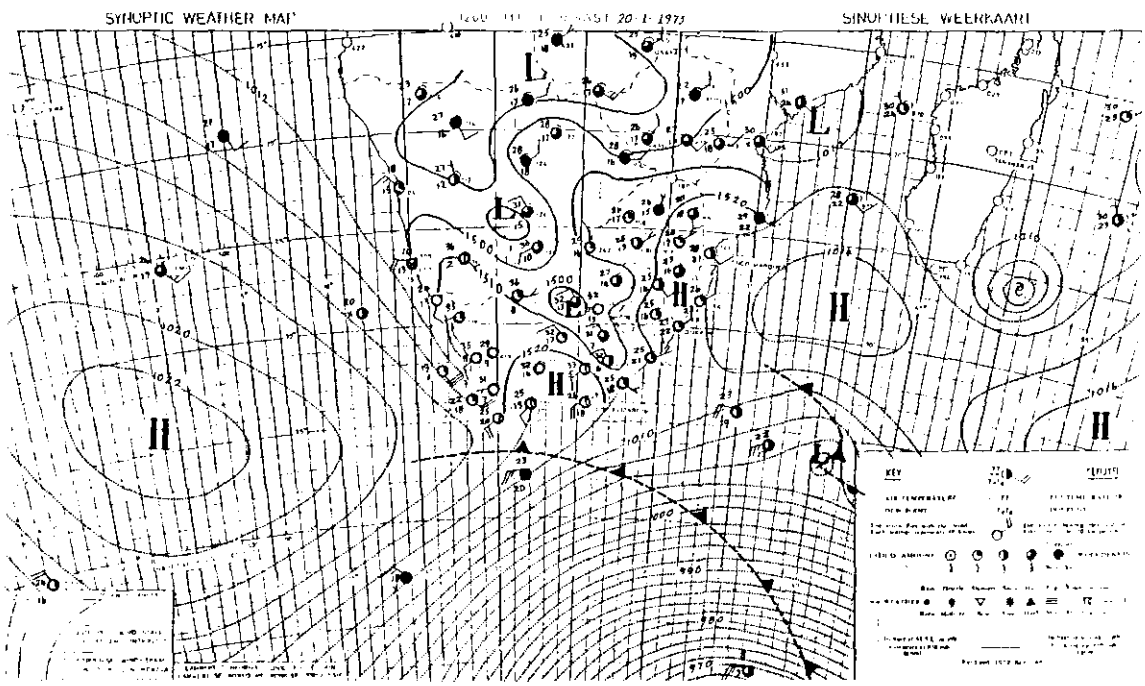

Fig. 4.29. Same as Fig. 4.27 except for 1200 GMT 20 January 1975

4.3 THE ISLANDS OF MAURITIUS AND REUNION, AND THE SEYCHELLES

4.3.1 Mauritius and Reunion (Islands east of Malagasy Republic)

The geographical locations of Mauritius and Reunion are shown in Fig. 1.1. Mauritius has a weather service and issues weather forecasts. Weather over Mauritius and Reunion falls into one of two basic patterns. Most of the year these islands are influenced by strong or moderate southeasterly winds and associated cool and dry conditions. This weather occurs in association with the strong Indian Ocean anticyclone. The anticyclone (and associated southeasterly flow) is most intense from June through September. During the period from September through March the southeasterlies are often interrupted when the subtropical anticyclone weakens sufficiently or withdraws from this portion of the Indian Ocean. Southeasterly flow is replaced by northerly flow of warm moist tropical air into the area. When the subtropical ridge is reestablished over the area, the southeasterlies are restored. The cool air from polar and mid-southern latitudes flows under and lifts the tropical air. Associated cloud development and rain shower activity is extensive and sometimes lasts for several days. Southeasterly flow can become strong in these situations (25 - 35 kt over water) if westward ridging of the subtropical anticyclone is intense. The second of the two basic patterns occurs when the anticyclone is replaced by a tropical depression south of Mauritius. This occurs most frequently from December through March. Weak northerly flow over the area is associated with these situations, and cumulonimbus clouds and convective rain shower activity is likely to develop in the afternoon. Occasionally thunderstorm activity develops in this situation (Naval Environmental Prediction Research Facility, 1980a).

a. Precipitation

Several types of rainfall affect Mauritius and Reunion at different times of the year. Orographic rains are light and most prevalent over these islands when strong southeasterlies are present. From November to April the islands come under the influence of weak tropical depressions and occasionally tropical cyclones. Rains associated with these systems are sometimes heavy but seldom steady. Heavy rain shower activity occurs for short periods (several hours), separated by periods of light rain. This kind of activity may continue for two to three days. Another type of rainfall occurs in association with frontal activity. This is convective rainfall, occasionally with thunderstorm activity (Naval Environmental Research Facility, 1980a).

The Mauritian rainy season lasts from December through April. Most of the rainfall occurs from January through March and is associated with passing tropical cyclones. The rainy season at Reunion occurs from November through April. Most of the rain falls from December through March, also in association with passing tropical cyclones. A significant portion of the rainfall on Reunion is orographically induced. The island's mountain range (maximum elevation - 8000 ft) is perpendicular to the southeasterly flow. Therefore, the east side of the island receives frequent rain showers in southeasterly flow while the west side

remains relatively dry. Rain shower activity over Reunion is generally discontinuous and seldom heavy (Naval Environmental Prediction Research Facility, 1980a).

4.3.2 Seychelles Islands (Islands northeast of Malagasy Republic)

The Seychelles Islands are positioned close enough to the equator (Fig. 1.1) so that they are under the influence of tropical air year round. Weather over the Seychelles Islands is dominated by east and southeasterly monsoonal winds from mid-April to mid-November. Sustained wind of 10 kt is typical during this period. Strongest flow (occasionally sustained wind 25 - 35 kt) occurs in July and August when the Indian Ocean subtropical high is strongest. The northwest monsoon (derived from the Northern Hemisphere northeast monsoon) moves over the islands in mid-November and dominates regional weather through mid-April. Winds associated with the northeast monsoon are light (mean flow 5 kt) and calms are frequent (November - January) (Naval Environmental Prediction Research Facility, 1980a).

a. Precipitation

The wet season is from November to March and the highest rainfall occurs in December and January. The driest period of the year is July and August. Rainfall gradually increases in September and October but in November there is a large increase in rainfall. This increase occurs in association with squall activity. Squalls occur over the Seychelles from November through January and are associated with low level turbulence and heavy rain showers. Winds are likely to increase rapidly to 25 - 35 kt (over land) with the approach of a squall. Despite the existence of the wet season from November to April during the northwest monsoon, Mahe, the largest of the Seychelles Islands, has experienced the maximum 24-h rainfall during the month of September while southeasterly flow still dominates (Naval Environmental Prediction Research Facility, 1980a).

4.3.3 Thunderstorms (Mauritius, Reunion and the Seychelles)

Thunderstorms occur only occasionally over Mauritius and Reunion. Over Mauritius the highest frequency of occurrence is from November to May. The maximum mean of five thunderstorms per month occurs in March. The most severe storms occur in association with nearby, passing tropical cyclones. During the months of December through March, unstable conditions occasionally develop in association with converging unstable northerly (warm moist) flow. Thunderstorm activity occasionally persists for two to three days when such flow develops. Over Reunion an average of ten thunderstorms are observed annually and virtually all of the activity occurs between November and April.

Thunderstorms over the Seychelles Islands are also infrequent. The maximum frequency of occurrence is from December through May (two to three per month). Activity is most likely associated with squalls and with tropical depressions passing south of the islands.

4.3.4 Tropical Cyclones Affecting the Islands

Tropical cyclones occur most frequently from November through April. Early in the season storms generally track east of the Malagasy Republic near Mauritius and Reunion or farther east. The storms develop farther west in December through March (see Table 4.1) (Naval Environmental Prediction Research Facility, 1980a). In April tropical cyclones generally develop and track a considerable distance east of Mauritius and Reunion. The Seychelles Islands seldom experience heavy weather (other than rain showers) in association with tropical cyclones as these systems generally pass well south of the islands before developing significantly. Information concerning these systems in the form of warning and bulletins is made available by the United States Navy/Air Force Joint Typhoon Warning Center, Guam (JTWC) and by the Mauritian Weather Service.